Effect of Light Tapering on Light Yield

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The question has arisen of whether sanding the longitudinal CsI crystal faces to taper the light collection along the length of a crystal affects the total scintillation light yield. We can address this question with data from the crystals we ordered from Amcrys-H (Ukraine), with dimensions 310 mm x 30 mm x 23 mm for the GLAST BTEM calorimeter. We conclude that **sanding appears to increase the light yield in the center of the crystal slightly,** by ~10%, although we cannot rule out the possibility that some of this change was the result of slow, long-term gain drifts in the test apparatus.

We received the Amcrys-H crystals "finely" polished on all surfaces, although they were clearly less well polished than crystals of the same size from Crismatec. We inspected each crystal visually, then measured the light yield at both ends from a ^{22}Na source (1275 keV) positioned at several locations along the length of the crystal. Some weeks later, typically about a month, we sanded the two 310 mm x 23 mm faces with 600-grit paper to taper the light such that the signal at the far of the crystal was 65% $\pm$ 15% of that at the near end. We then repeated the light yield measurement along the length of the crystal, in this case at a greater number of locations.

The tests were performed in a dark box, with Hamamatsu R669 red-sensitive PMTs covering all of each end face of the crystals. The crystal faces were in dry contact with the PMT faces. The crystals were wrapped in Tyvek and aluminum foil. The PMTs used separate high voltage supplies and separate amplifier and ADC chains. We chose PMT voltages and shaper gains to give equal-amplitude signals at both ends. We used our two-channel "Marge" data acquisition system, which supports either list-mode or histogram-mode output and controls a stepper motor to translate a radioactive source in one dimension. We logged a spectrum from each PMT at each location and fit with a gaussian line profile.

In both the "pre-sanding" and "post-sanding" scans, we collected data at 140 mm and 170 mm from the left-hand side (LHS) of each crystal. These locations are close to and equidistant from the center of the 310 mm crystals. The average of the 1275-keV peak centroids at these locations should then be a measure of the light yield at the center of the crystal. For this study, we compared the average centroids measured from the LHS and right-hand side (RHS) after the sanding with those measured before the sanding.

Table 1 shows the percentage change in the light yield measured at the LHS and RHS after sanding. The Amcrys H crystals are identified with their NRL reference number, and the dates of the tests before and after sanding are indicated. In most – but not all – cases, the interval between measurements was about a month. In all but one case, the light yield *increased* after sanding, typically by ~10%. Although there are some exceptions, typically the LHS and RHS changes are well correlated, i.e. the change in light yield is observed on both ends.

Note that some crystals appear in the list twice. In those instances, the first sanding gave a light taper that was too steep, and we repeated the sanding. The second measurement then typically followed the first within about 10 days. The second change in light yield was comparable to the first, a few to ~10%, although the one instance (U-02-30) of a decrease in light yield from sanding is followed by an increase with the second sanding.

Thus it appears that the light sanding of the long surfaces of the crystals increases the average light yield slightly. We cannot rule out that some of this change results from a slow, upward drift in gain in the test apparatus, although the similarity of the changes over short time intervals with those over long intervals, the separate HV supplies, and the general consistency of results from end to end and crystal to crystal argue against this.

Crystal ID	Pre-sanding test	Post-sanding test	% change, LHS	% change, RHS
U-01-01	12-May-99	01-Jun-99	1.5	10.9
U-01-01	01-Jun-99	10-Jun-99	1.6	3.8
U-01-02	12-May-99	10-Jun-99	5.5	4.7
U-01-03	12-May-99	10-Jun-99	1.9	1.3
U-01-04	12-May-99	10-Jun-99	3.8	5.1
U-02-01	21-Apr-99	30-Apr-99	7.2	6.0
U-02-02	22-Apr-99	30-Apr-99	4.8	3.9
U-02-04	22-Apr-99	29-Apr-99	3.7	2.2
U-02-30	06-May-99	04-Jun-99	-8.4	-9.9
U-02-30	04-Jun-99	14-Jun-99	14.0	13.7
U-02-31	06-May-99	04-Jun-99	7.7	13.5
U-02-32	06-May-99	03-Jun-99	11.4	16.2
U-02-32	03-Jun-99	14-Jun-99	2.5	1.1
U-02-33	06-May-99	07-Jun-99	5.8	10.4
U-02-33	07-Jun-99	15-Jun-99	7.7	5.6
U-02-35	07-May-99	08-Jun-99	8.7	10.9
U-02-36	07-May-99	08-Jun-99	13.6	9.7
U-02-37	07-May-99	08-Jun-99	14.7	21.2
U-02-38	07-May-99	08-Jun-99	13.7	18.9
U-02-40	10-May-99	09-Jun-99	16.1	17.9
U-02-41	10-May-99	09-Jun-99	16.0	18.7
U-02-42	10-May-99	09-Jun-99	8.8	15.7
U-02-43	11-May-99	09-Jun-99	10.6	15.6
U-02-44	11-May-99	09-Jun-99	19.9	18.0
U-02-45	11-May-99	09-Jun-99	20.2	20.0
U-02-46	11-May-99	08-Jun-99	17.8	18.9

Table 1: Percentage change in light yield following the application of light tapering to crystals from Amcrys H.